Recent progress on laser driven acceleration and applications at LBNL

Wim Leemans
l'OASIS Group, Center for Beam Physics
LBNL

Laser-plasma accelerators (LPAs) are potential next generation sources of energetic electrons, providing accelerating gradients up to hundreds of GV/m to allow compact devices. Previous experiments used no external method for laser guiding, limiting the acceleration distance and resulting in 100% electron energy spread. Recently, high energy electron beams with narrow energy spread from an LPA by guiding the drive pulse in a pre-formed plasma channel over a distance of 10 ZR. The experiments were carried out using the multi-beam l'OASIS facility at LBNL. Plasma channels were produced with the ignitor-heater method in which a short (50 fs) intense laser pulse (ignitor) pre-ionizes hydrogen from a gas jet, and a second laser pulse (200 ps long) inverse Bremsstrahlung heats the plasma. The hydrodynamic radial expansion led to the formation of a density channel that is well suited for guiding intense laser beams. A third laser beam was focused at the entrance to the plasma channel and guiding of this beam over a wide parameter range including the first demonstration of guiding relativistic intensities in pre-formed channels. For power levels above 5 TW and with appropriate input coupling, the channel guided LPA produced accelerated electron bunches. Bunches with a few percent energy spread, hundreds of picocoulombs of charge, and mrad divergence at above 80 MeV beam energies have been observed. This represents a major, qualitative improvement over unguided LPAs, with at least a factor of 200 greater charge per MeV at high energy and a factor of 10 smaller divergence as well as finite energy spread. The acceleration gradients (near 50 GV/m) of previous LPA experiments are retained over many times the distance, the beam quality approaches that of state of the art RF accelerators, allowing new classes of experiments with LPAs. Applications of laser driven accelerators are also pursued such as generation of coherent far-infrared and THz radiation, production of femtosecond x-ray pulses by laser accelerated electron bunches, and radio-isotope production of positron emitters.